Simulation of External Pacing and Arrhythmia Management: A Novel Training Experience

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***Abstract*— Proper operation of a temporary external pacemaker is critical in treating patients who undergo open-heart surgery. However, an appropriate training system does not currently exist. Therefore, we developed a novel simulation platform that provides practical experience in epicardial pacing by simulating a patient's heart in a manner that provides realistic and real-time feedback in a controlled environment. The device interfaces with any patient monitor and any temporary external pacemaker. This allows for the device to be integrated into an existing simulation environment or to facilitate a portable training session within the hospital.**

I. Introduction

Approximately 500,000 open-heart surgeries are performed in the United States each year, and up to half of these post-operative patients will require some form of temporary epicardial pacing in order to correct abnormal heart rhythms [1]. These high-risk, low-frequency cardiovascular complications require skilled caretakers to pace the heart appropriately by manually adjusting parameters on a temporary external pacemaker [2]. Improper treatment can result in severe adverse effects, including death. However, there is currently no means for healthcare providers to gain hands-on experience with the pacemaker prior to use on a patient. The standard of education consists of lectures and lacks dynamic interaction. Therefore, we developed a simulation platform that enables caretakers to train on the use of a temporary external pacemaker and provide them with accurate, real-time feedback.

II. System Architecture

The simulation platform consists of a small box (Figure 1) containing electrical circuitry that simulates a patient's heart rhythm. The device communicates with and responds to the pacemaker, as well as outputs an electrocardiogram (ECG) to the patient monitor. On one side of the device are four ports, two for each of the atrium and ventricle, that support dual-chamber pacing with unipolar wires. On the opposing side are three ECG lead connections that represent the Left Leg (LL), Left Arm (LA), and Right Arm (RA) of a simulated patient and output the heart rhythm to Lead II on the patient monitor. Furthermore, we developed an iOS application that provides the trainer wireless control of the device (the simulated patient) as well as the ability to create clinical scenarios of their choosing. The ECG output on the patient monitor depends on the simulated patient's condition set by the trainer and dynamically responds to input from the pacemaker, which is toggled by the trainee. The device simulates a variety of arrhythmias including ventricular tachycardia, JET, AV block, and sinus node dysfunction. Concepts such as loss of capture, and over-sensing or under-sensing can be taught using this device.

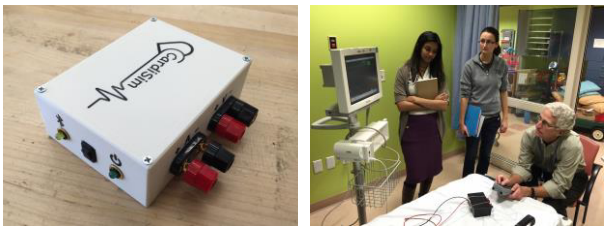

Figure 1. *Left:* Device shown with connections for the atrial and ventricular leads to the pacemaker. *Right*: A trainee pacing the simulated patient.

III. Evaluation and Conclusion

Our device creates a means for healthcare providers to practice using a temporary external pacemaker while receiving real-time feedback and without putting a patient at risk. Preliminary testing in a hospital setting resulted in positive reviews of the device. We are currently developing a curriculum using this device to train healthcare providers on external pacing within a high-fidelity simulation setting.

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